

# Biofuels – Opportunities for Tennessee

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# Conversion routes to biofuels

1,126 flex cars in TN in 2000, now more than 10,000

Source: DOE/EERE

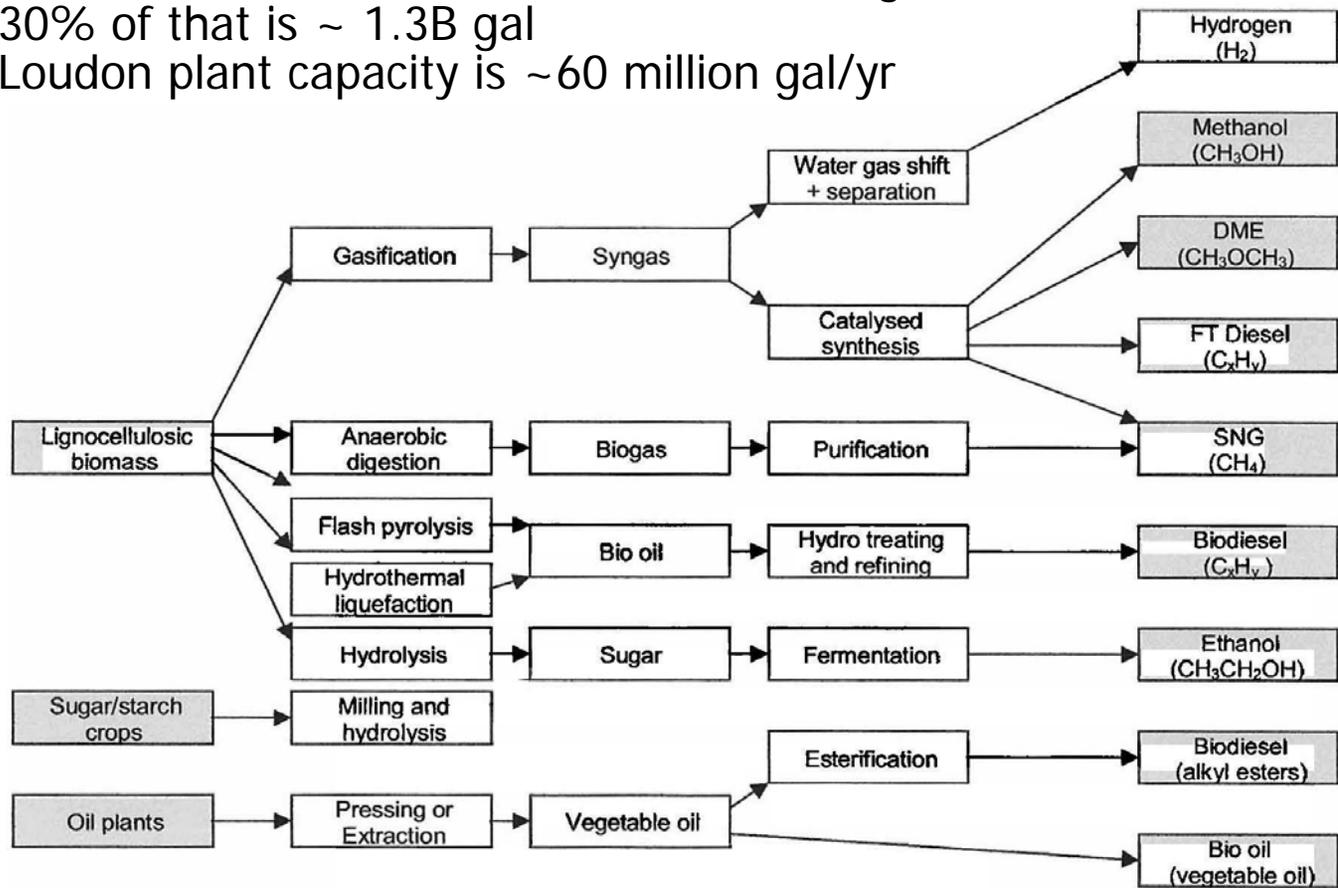
Renewable transportation fuel <1% of total consumption

2001 per capita petroleum transportation fuel consumption: 18 barrels or 756 gal

5.8 million inhabitants in 2000 -> ~ 4.4B gal

30% of that is ~ 1.3B gal

Loudon plant capacity is ~60 million gal/yr



EtOH station in San Diego, CA – one of 600 in the US

# Issues and facts in corn ethanol (EtOH)

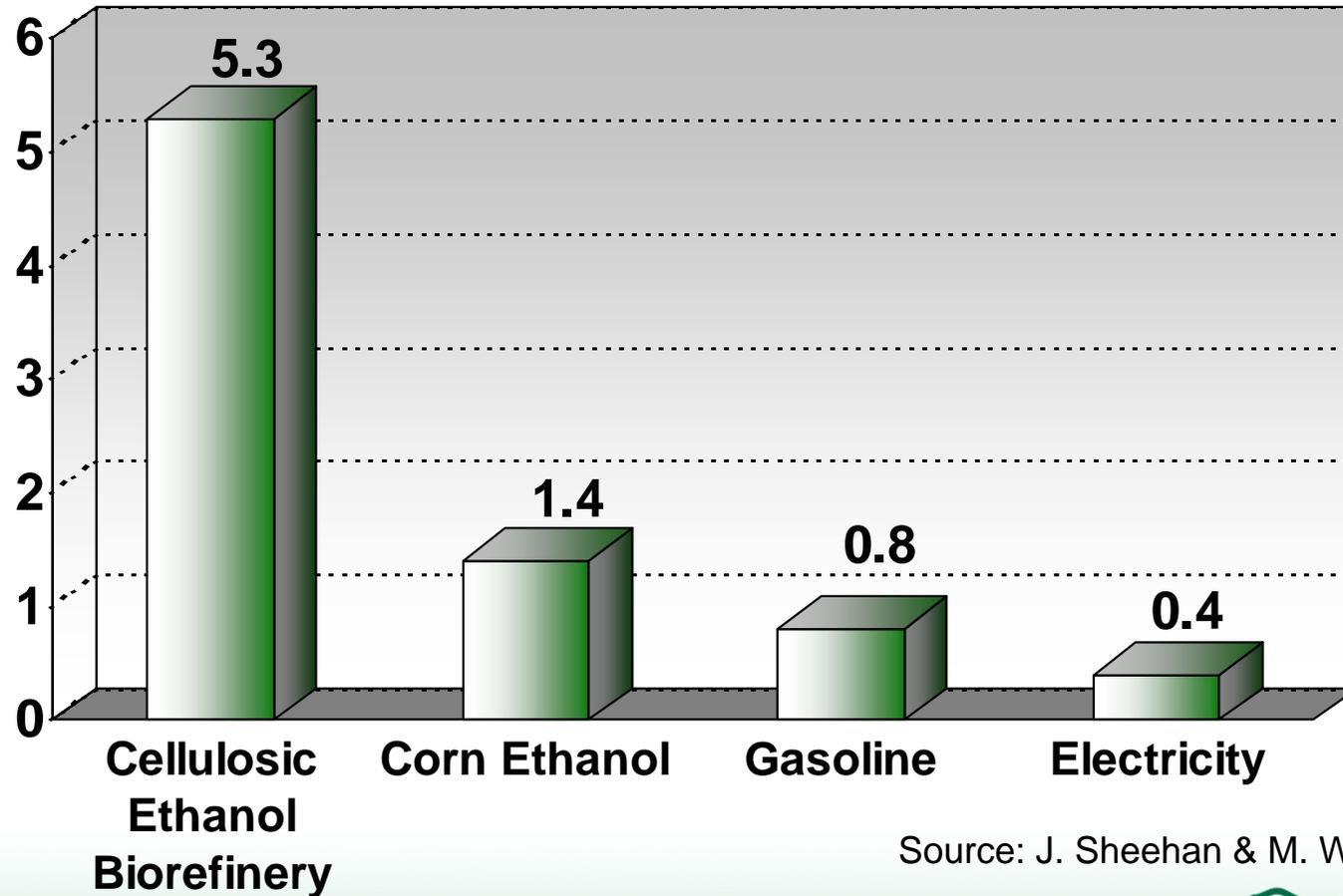
- In the conversion routes chart, we should focus on ethanol, biodiesel, hydrogen
- New corn dry mill plant for ethanol
  - Average cost to build - \$100M
  - Produce ~ 70M gal of EtOH, from 26 M bu or 0.7 Mt of corn
  - Production cost ~\$0.6/gal
- The one EtOH plant in TN uses corn largely imported from other states
- TN corn output is 86 M bu out of 12 B bu U.S. (2004)
- US production of EtOH from corn is ~4.5B gal in 2005, another 2.5 B gal capacity planned by 2008
- The Renewable Fuel Standard demand is 7.5B gal to replace MTBE in gasoline by 2010
- Capacity to grow corn limits annual EtOH production to less than 15 B gal/yr without impacting food and feed

# Issues and facts in cellulosic ethanol

- Cellulose to EtOH feasible now but not economical (>\$2/gal)
- R&D is expected to bring this down to <\$1/gal
- Variety of sources of cellulose, more abundant supply than corn, better suited for TN
- Almost 5 times more energy delivered per fossil energy unit used for cellulose to EtOH compared to corn (see next chart)
- Estimated construction cost to build cellulose to EtOH production plant with comparable 70 M gal/y capacity is:
  - Today's technology estimate is ~\$200M with potential \$100M reduction from improvements
  - Ultimate construction cost comparable to \$100M corn plant
  - Economies of scale make larger better – thus 3-4 M ton biomass/d is at lowest end, most designs are 5 to 25 M ton biomass/d
- Huge opportunity in the Southeast to have alternate use for forest products (pulp & paper diminishing)
- Gasoline pipelines not likely usable by ethanol

# Fossil Energy Replacement Ratio

$$\text{Fossil Energy Ratio (FER)} = \frac{\text{Energy Delivered to Customer}}{\text{Fossil Energy Used}}$$



Source: J. Sheehan & M. Wang (2003)

# Issues, facts – cont.

- Biodiesel
  - Mature processing technology, grease competitive but 100M gal/y
  - Large amounts of co-product glycerol produced, R&D required
  - Ultimate impact is seen as limited due to limits on feedstock growth and cost (largely soybean in US)
    - Plant genomics and engineering can have significant impact,
    - soybean genome being sequenced,
    - tropical plants like oil palm or “diesel tree” *Copaifera* may offer understanding to improve biodiesel properties
- Biomass gasification into Syngas or power
  - Technologies exists at various scales and maturities – esp. for power
  - R&D issues in conversion of syngas into liquid transportation fuels
  - Some proponents say commercial now or within 10 y.
- Hydrogen
  - Most see as technology for 20-50 y in future
  - R&D issues in infrastructure, cost, yield
  - For TN, most likely from syngas from biomass

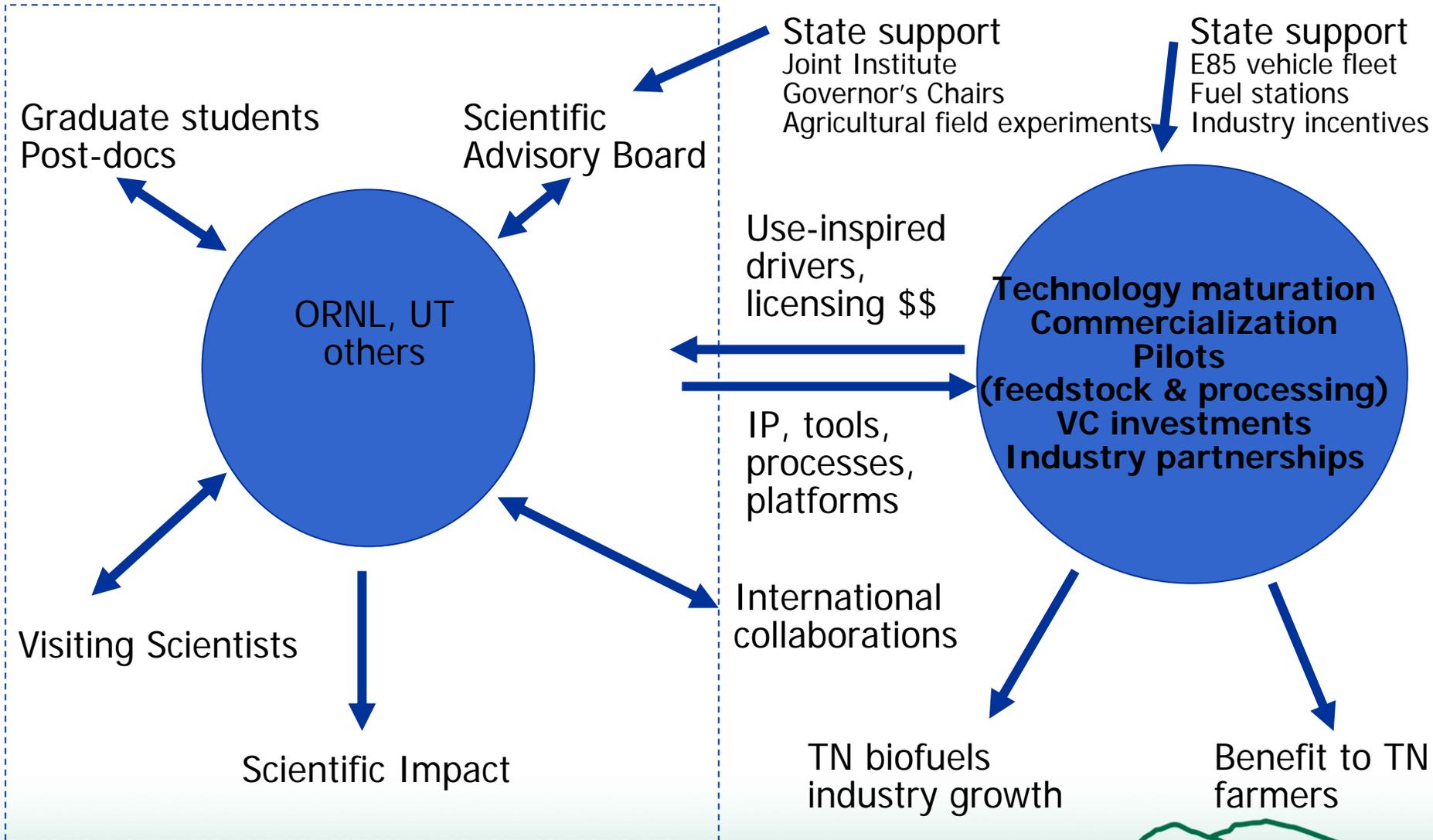
# DOE Bioenergy Center – an opportunity for UT/ORNL with partners to secure a \$25M/yr federal investment

- To be issued July 2006, deadline for full proposals early 2007, awards mid-2007
- Two awards to be made – approximately \$25M/yr each, no construction funds
- Focus on science for biofuels
- Institutional and State support, effective constituency, will enhance our competitive advantage
- Expect fierce competition

# Bioenergy Center

## Science

## Translation and Application



# Summary

- Significant opportunity in TN for increased penetration of biofuels
- Strong scientific base from which to solve grand challenges in cost-effective cellulosic EtOH production, and other biofuel challenges
- Significant federal R&D investment (DOE) to be competed within the next six months
- Partnership State/UT/ORNL/industry will be critical factor in our ability to win